State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Aquatic Resources
Honolulu, Hawaii 96813

March 24, 2006

Board of Land
and Natural Resources
Honolulu, Hawaii

THE DIVISION OF AQUATIC RESOURCES REQUESTS BLNR AUTHORIZATION/APPROVAL TO ISSUE TWO (2) NORTHWESTERN HAWAIIAN ISLANDS (NWHI) ACCESS PERMITS TO THE NATIONAL MARINE FISHERIES SERVICE: 1) A RESEARCH, MONITORING & EDUCATION PERMIT FOR ASSESSMENT OF REFUGE RESOURCES (MONITORING CETACEANS, ENHANCING MONK SEAL PUP SURVIVAL AND SMALL BOAT OPERATIONS); AND 2) SPECIAL ACTIVITY PERMIT (ALLOWING ENTRY TO STATE WATERS SURROUNDING THE NWHI)

Submitted herewith for your authorization and approval is a request for issuance of two NWHI Access Permits to the National Marine Fisheries Service's (NMFS) Pacific Island Fisheries Science Center (PIFSC) and the NOAA/NMFS Research Vessel *Oscar Elton Sette*. The permits, as described below, authorize access and activities in State waters around the NWHI. The Research, Monitoring and Education Permit will allow activity to occur in the NWHI State Marine Refuge (0-3 miles) waters surrounding Nihoa Island, Neck Island, French Frigate Shoals, Laysan, Gardner Pinnacles, Lisianski Island, Neva Shoal, Pearl and Hermes Atoll, Kure Atoll-State Wildlife Refuge, in support of monk seal field camps and to survey/sample cetaceans. Extensive small boat operations will occur within the lagoons at Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals as part of monk seal monitoring. The Special Activity Permit will allow the NOAA Research vessel *Oscar Elton Sette* entry to State waters surrounding the NWHI. The activities covered under these permits are from April 8, 2006-September 15, 2006 as outlined below and in the attached permit applications.

Monk seal and turtle monitoring is part of a long term project to track the status of the affected species within the Hawaiian Archipelago. Data from cetacean monitoring will be added to data collected throughout the North Pacific as part of the Structure of Populations, Levels of Abundance and Status of Humpacks Project. Information on nearshore populations of spinner dolphins will be shared with collaborators at the University of Hawaii. Data and samples from shark monitoring will be shared with researchers from Hawaii Institute of marine Biology as well as other appropriate researchers as part of research on contaminants, DNA, and distribution of sharks throughout the NWHI.

1) RESEARCH, MONITORING AND EDUCATION PERMIT: The proposed activities are consistent with and support the purposes of the Refuge, primarily assessment of refuge resources, e.g. monitoring cetaceans and providing boat support to personnel monitoring monk seals and turtle nesting. They are also part of a long-term research data set that provides critical information for management of various threatened and endangered species.

    a) Monitoring and sampling of cetaceans: Most of the cetacean species for which PIFSC has assessment responsibility occur throughout the Central and Western Pacific Ocean, and the ability and opportunity to gather data them are limited. The proposed activity will take

advantage of vessel transit to the NWHI (to support other activities of the Protected Species Division) by observing and sampling cetaceans, some of which may occur within the boundaries of the State Marine Refuge. Moreover, knowledge of the genetic distribution of nearshore cetacean species within the Archipelago (spinner dolphins) is required in order to assess the degree to which the populations mix. Three populations of spinner dolphins occur within the NWHI Marine Refuge (Kure, Pearl & Hermes Atoll, French Frigate Shoals).

Most cetacean monitoring will occur during transit between the NWHI and will, therefore, be outside the Refuge boundaries. However, during camp deployment and pickup at French Frigate Shoals and/or Pearl & Hermes Atoll, small boats may be deployed to collect samples from bottlenose dolphins and spinner dolphins. Biopsy samples will be collected from free ranging animals using biopsy dart fired from a crossbow, standard methodology for collecting cetacean skin/blubber biopsies. Biopsy pugs are ~2mm in diameter and 1-2 cm long, and provide genetic information (skin) as well as data on contaminants (blubber). Note sampling of inshore populations at French Frigate Shoals and Pearl & Hermes Atoll will occur only with the *Oscar Elton Sette* is in the area for field camp setup/breakdown. Field personnel who are at these two sites to monitor monk seals will not be collecting biopsy samples.

b) Enhance survival of Hawaiian monk seal pups: Survival of Hawaiian monk seal pups at French Frigate Shoals is compromised by Galapagos sharks. These events have been documented only at French Frigate Shoals; therefore, efforts to mitigate against Galapagos shark predation must occur there. Seven years of intensive observations have revealed that Galapagos sharks hunt or pursue pre-weaned monk seal pupus in shallow water during monk seal pupping season. This behavior was persistent and predictable, and can be used therefore to target individual sharks for removal. Galapagos sharks identified for removal will have exhibited conspicuous predatory behavior, defined as actively pursuing or hunting for pre-weaned pups in water less than two meters deep. Predefined sighting areas will be designated for fishing activities, and targeting/culling of sharks will involve hooks, harpoon, and/or the option of using a high-powered rifle. The application requests approval for the removal of up to 15 Galapagos sharks.

c) Small boat operations: Subpopulations of Hawaiian monk seals will be monitored throughout the NWHI and, in cooperation with USFWS, monitoring of green turtle nesting activity at East Island, French Frigate Shoals. These activities require small boat operations within the lagoons of Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals.

Whalers will be used to transport personnel among islets at Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals, primarily for the purpose of censusing and monitoring Hawaiian monk seals, but also to transport personnel between East Island and Tern Island, French Frigate Shoals, to monitor turtle nesting. Boat operations will occur virtually daily for the duration of the project at Pearl & Hermes Atoll and French Frigate Shoals, and approximately every third day at Kure Atoll. At night boats will be hauled out (French Frigate Shoals) or anchored in nearshore waters of Southeast Island (Pearl & Hermes Atoll) or Green Island (Kure Atoll). When accessing other islets within the lagoons, depending upon conditions, personnel will generally anchor the boats in shallow water adjacent to the islets, bow facing in, with a stern anchor leading offshore and a bow anchor placed on the islet. Stern anchors will always be placed on a sandy bottom. If conditions preclude safely anchoring the boat while accessing the islets, one observer will remain in the small boat as coxswain and will stay on station away from the islet while co-workers census seals.

REVIEW PROCESS:

The permit was received by the Division of Aquatic Resources on Monday March 13, 2006. Staff had only a few days to review and provide comments on this permit and to try to make final recommendations. The majority of the research covered under this permit is annual routine work that has occurred year-after-year. Due to the permit guidelines only being approved at the Feb. 24, 2006 Land Board meeting, and given that final edits based on public comments at this meeting were competed on February 29, 2006, there was very little time on the part of the applicant to provide all the data necessary to complete the application and give it to staff to review in time to meet the Land Board agenda.

The permit review committee is still in the process of being finalized. The timeline under which this permit must be issued is protracted as the ship sails on April 1, 2006 to take the researcher up to their field camps for their annual studies. Since the permit review process is still being finalized, key staff within the Department were asked to comment and provide recommendations on this permit. Staff recommendations are summarized below:

STAFF RECOMMENDATIONS:

Three staff were asked to review and/or comment on this document. A summary of recommendations from each staff are outlined below, with final recommendations based on staff input also attached.

Staff member one is our protect species program coordinator and sits on the Hawaiian monk seal recovery team. He is familiar with all the issues regarding the critical decline in the monk seal populations and has no problems with any parts of the activities outlined in this permit.

Staff member two is a shark expert and familiar with all issues relating to sharks in the Main Hawaiian Islands. He had no concerns about the cetaceans work, nor with the monk seal recovery team operations. His concerns relate mainly to the proposed culling of sharks at Trig Islet in French Frigate Shoals. He had several questions regarding the viability of being able to identify the Galapagos sharks that are the true predators on the monk seal pups. He was also not sure that the data exists given annual fluctuations in climatic conditions to justify and ensure that predation behavior is not more variable than outlined in the application. He was concerned about the use of high-powered rifles and did not think that this would be an effective method to kill the sharks and may create more of a problem by attracting more sharks to the area to feed on the wounded shark. The catch per unit of effort of current shark culling is very low and he recommends that we allow them to only take 5 sharks at a time and then come back in for a request for authorization to take 5 more. He also recommended capping the total number of sharks at 10. Lastly, he recommends that the final report include an analysis of catch per unit of effort for methods used to catch the sharks.

Staff member three is a Native Hawaiian and works for the Kahoolawe Island Reserve Commission. He consulted with several Native Hawaiian practioners who had no comment on the monk seal camps or cetacean work; however they felt that culling sharks is not justified. Attached is an analysis from the Kaho'olawe Island Reserve Commission stating their position.

Staff also asked for input from the US Fish and Wildlife Service (FWS) and the NWHI Coral Reef Ecosystem Reserve (Reserve). The FWS has yet to issue a permit for this activity. No comments were received from the Reserve at the time of this submittal.

FINAL STAFF RECOMMENDATION:

Approve the cetacean and monk seal work, outlined as small boat vessel operations. Conditionally approve the shark culling program with the following conditions:

- Allow only 5 sharks to be taken at a time. Limit the total take/killing of sharks to 10 sharks.
- Require the National Marine Fisheries Service to request additional approval by providing ample justification on why additional shark killing is needed. Include an analysis of the catch per unit of effort for removals. Allow additional take to be approved by the Chairperson, as a representative of the Board,
- Do not approve the request for the use of high-powered rifles.
- Ensure that all additional concerns that may be raised by the US FWS are incorporated into the final permit conditions.

2) SPECIAL ACTIVITY PERMIT: This permit will allow NOAA's scientific vessel, *Oscar Elton Sette*, to transit through waters surrounding the NWHI and allow entrance to all the NWHI. The vessel requires access in order to support the activities listed in the above Research, Monitoring and Education permit.

REVIEW PROCESS:

No review process has been undertaken as the permit application is still pending and will be submitted at the Land Board meeting. The ship has been at sea and time constraints have made submission in a timely manner a challenge.

STAFF RECOMMENDATIONS:

No staff recommendations were sought due to the time constraints.

FINAL STAFF RECOMMENDATION:

Allow the NOAA Research Vessel *Oscar Elton Sette* entry into State waters to perform activities outlined under the Research, Monitoring and Education permit. Ensure all permit conditions outlined in the BLNR permit guidelines are applied.

RECOMMENDATION:

"That the Board authorize and approve, with stated conditions, a Research, Monitoring and Education Permit and Special Activity Permit to the National Marine Fisheries Service and the *Oscar Elton Sette*, for activities and access within the NWHI."

Respectfully submitted,

DAN POLHEMUS
Administrator

APPROVED FOR SUBMITTAL:

PETER T. YOUNG
Chairperson

LINDA LINGLE
GOVERNOR OF HAWAI'I

K_KULU KE EA A KANALOA

COMMISSION MEMBERS

NOA EMMETT ALULI, M.D.
Chairperson
BURT H. SAKATA
Vice-Chair
MILTON M. ARAKAWA, A.I.C.P.
CHARLES PMK BURROWS, Ed.D.
ROBERT J. LU'UWAI
JOHN D. WAIHE'E, IV
PETER T. YOUNG

SOL P. KAHO'OHALAHALA
Executive Director

KAHO'OLAWE ISLAND RESERVE COMMISSION

811 Kolu Street, Suite 201, Wailuku, HI 96793
Telephone (808) 243-5020 Fax (808) 243-5885

March 17, 2006

MEMORANDUM

To: Athline M. Clark
Special Projects Program Manager
Hawaii Division of Aquatic Resources
Department of Land and Natural Resources
1151 Punchbowl St. Rm. 330
Honolulu, Hawaii 96813

From: Sol P. Kaho`ohalahala
Executive Director, KIRC

Subject: Pacific Islands Fisheries Science Center NWHI Application

I appreciate the opportunity to make comments on the permit application for a new research, monitoring and education project in the State Marine Refuge. In this brief review period I submit the following comments below in light of my current capacity as the person responsible for the resources management of the Kaho'olawe Island Reserve and as one who supports the preservation and practice of all rights customarily and traditionally exercised by native Hawaiians for cultural and subsistence purposes.

Further, the comments made herein are in consultation with marine and cultural experts. These are our collaborative concerns:

We are concerned that the applicant places value on one native species over another native species in a pristine marine habitat. The perception is that of humans attempting to play or assume the role of "creator". From a cultural perspective, we believe that the Northwest Hawaiian islands are our kupuna islands in a natural state of balance or pono.

We raise the following issues for further consideration and elaboration:

- There seems to be a lack of concern on the importance of the Galapagos shark on the ecosystem impacts in the terms of weeding the sick monk seals.

- It is inferred that when unweaned pups disappear it is due to shark predation.

- There is no discussion or evidence of other interactions such as other predators like ulua that dominate the nearshore waters.

- Is there impact by disease?

- Are there observations on the "aggressive males" and their impact on pups?

- The large variance between confirmed, probable and possible is of great concern. I would like to see overall mortality and not just assume that "disappearances inferred to be predation due to absence of any other comprising factors". The kupuna islands are complex ecosystems that should not be simply reduced to generalizations about predation and mortality, more research is needed before the request to remove or kill another native species.

- The carcass of pups with wounds from the Galapagos sharks can't always dictate that the actual death was caused by a Galapagos shark. The mano are scavengers also.

- Research simulated models seem to indicate that the culling of Galapagos sharks will have no effect on the ecosystem. I would like input from native Hawaiian practitioners, Allen Friedlander, Randy Kosaki, invertebrate biologist, botanist and input from the Northwestern Hawaiian Island regional council. How can they say "no effect" when you remove an apex predator in an apex predator dominated ecosystem.

- Need to have more input from Native Hawaiians and their inclusion in the Pacific Islands Fisheries Science Center.

- Finally the deaths of seal pups while tragic were part of a natural process. If mortality from a non-native or non-natural process occurred then there should be concern and action.

In closing, let me briefly reiterate the fact that our native Hawaiian ancestral belief system continues to be guided by Kupuna who constantly remind that pono, the balance between gather and restoring, exists as a practice that was pertinent then and now.

There are more questions that are raised with review of this permit application. It is our position at this time that the request to cull sharks is not justified.

Mahalo.

APPENDIX 1

State of Hawai'i
DLNR
Northwestern Hawaiian Islands State Marine Refuge
Permit Application Form
Draft

For Office Use Only	
Permit No:	
Expiration date:	9/15/06
Date Appl. Received:	3/13/06
Appl. Fee received:	N/A
NWHI Permit Review Committee date:	N/A
Board Hearing date:	3/24/06
Post to web date:	3/17/06

Type of Permit

☒ I am applying for a **Research, Monitoring & Education** permit. (Complete and mail Application)
- ☒ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.

☐ I am applying for a permit for a **Native Hawaiian** permit. (Complete and mail Application)

- ☐ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.

☐ I am applying for a **Special Activity** permit. (Complete and mail Application)

- ☐ This application is for a NEW project in the State Marine Refuge.
- ☐ This application is for an ANNUAL RENEWAL of a previously permitted project in the State Marine Refuge.

Briefly describe **Special permit** activity:

When will the NWHI activity take place?

☒ **Summer** (May-July of __2006___ (year)
Note: Permit request must be received before February 1st
Specific dates of expedition ___~April 6, 2006 through ~September 15, 2006___

☒ **Fall** (August-November) of _2006___ (year)
Note: Permit request must be received before May 1st
Specific dates of expedition ___~April 6, 2006 through ~September 15, 2006____

☐ **Other**

NOTE: INCOMPLETE APPLICATIONS WILL NOT BE ACCEPTED

Please Send Permit Applications to:

NWHI State Marine Refuge Permit Coordinator
State of Hawai'i
Department of Land and Natural Resources
Division of Aquatic Resources
1151 Punchbowl Street, Room 330
Honolulu, Hawai'i 96813

NWHI State Marine Refuge Permit Application
See Appendix 2 for Application Instructions

Section A – Applicant Information

1. Project Leader (attach Project Leader's CV or resume) ☒ CV attached Antonelis, George A. (Bud) Name: Last, First, Middle Initial	 Chief, Protected Species Division (PSD) Title
2. Mailing Address (Street/PO Box, City, State, Zip) 2570 Dole St. Honolulu, HI 96822	Telephone (808) 983-5710 Fax (808) 983-2902 Email Address bud.antonelis@noaa.gov
3. Affiliation (Institution/Agency/Organization) Pacific Islands Fisheries Science Center (PIFSC) National Marine Fisheries Service	For graduate students, Major Professor 's Name & Telephone

4. Sub-Permittee/Assistant Names, Affiliations, and Contact Information ☒ CV or resume attached

Following personnel affiliated with Pacific Islands Fisheries Science Center: Jason Baker, George Balazs, Brenda Becker, Ray Boland*, Robert Dollar*, John Henderson, Thea Johanos-Kam, Charles Littnan, Shawn Murakawa, Frank Parrish, Melissa Snover*, Chad Yoshinaga. Following personnel affiliated with Research Corporation of the University of Hawaii: Maire Cahoon, Suzanne Canja, Cody Hooven*, Dave Johnston*, Lizabeth Kashinsky, Stacy Kubis, Darin Padula*. Following personnel affiliated with Aquatic Farms, Ltd.: Veronica de Camp, Hugh Finn, Melinda Fowler, Antonette Gutierrez, Jean Higgins, Gretchen Johnson, Jessica Lopez, Leona Laniawe, Kenady Reuland, and Tracy Wurth. Private contractors include: Robert Braun, DVM, Aaron Dietrich*, Malcolm Gaylord, Bert Harting, Greg Levine, DVM. Dan Luers*, Marc Rice, Konrad Schaad, Mark Windham*, and Daniel Zatz.

*Resume not attached but will be provided prior to initiation of the activity.

5. Project Title
Protected Species Monitoring

6. Applicant Signature	7. Date (mm/dd/yyyy) 03/09/2006

Section B: Project Information

8. **(a) Project Location**

☒ NWHI State Marine Refuge (0-3 miles) waters surrounding:

- ☒ Nihoa Island
- ☒ Necker Island (Mokumanamana)
- ☒ French Frigate Shoals
- ☒ Laysan
- ☐ Maro
- ☒ Gardner Pinnacles
- ☒ Lisianski Island, Neva Shoal
- ☒ Pearl and Hermes Atoll
- ☒ Kure Atoll, State Wildlife Refuge
- ☐ Other NWHI location

Describe project location (include names, GPS coordinates, habitats, depths and attach maps, etc. as appropriate).

Activity will occur in the nearshore waters of all islands specified above in support of monk seal field camps and to survey/sample cetaceans. Extensive small boat operations will occur within the lagoons at Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals as part of monk seal monitoring.

(b) check all actions to be authorized:

☒ Enter the NWHI Marine Refuge waters

☐ Take (harvest) ☐ Possess ☐ Transport (☐ Inter-island ☐ Out-of-state)

☒ Catch ☒ Kill ☒ Disturb ☒ Observe

☒ Anchor ☒ Land (go ashore) ☐ Archaeological research

☒ Interactions with Sea Turtles or Monk Seals ☒ Interactions with Seabirds

☐ Interactions with Live Coral, Ark Shells or Pearl Oysters

☒ Interactions with Jacks, Grouper or Sharks

☐ Conduct Native Hawaiian religious and/or cultural activities

☐ Other activities _____

(c) Collection of specimens – collecting activities (would apply to any activity):

Organisms or objects (List of species, if applicable, add additional sheets if necessary):

Common name	Scientific name	No. & size of specimens	Collection Location(s)
Rough-toothed dolphin	*Steno bredanensis*	20 Skin biopsy	Any NWHI location
Risso's dolphin	*Grampus griseus*	20 Skin biopsy	Any NWHI location
Bottlenose dolphin	*Tursiops truncatus*	20 Skin biopsy	Any NWHI location
Pantropical spotted dolphin	*Stenella attenuata*	20 Skin biopsy	Any NWHI location
Spinner dolphin	*Stenella longirostris*	20 Skin biopsy	Any NWHI location
Striped dolphin	*Stenella coeruleoalba*	20 Skin biopsy	Any NWHI location
Fraser's dolphin	*Lagenodelphis hosei*	20 Skin biopsy	Any NWHI location
Melon-headed whale	*Peponocephala electra*	20 Skin biopsy	Any NWHI location
Pygmy killer whale	*Feresa attenuata*	20 Skin biopsy	Any NWHI location
False killer whale	*Pseudorca crassidens*	20 Skin biopsy	Any NWHI location
Killer whale	*Orcinus orca*	20 Skin biopsy	Any NWHI location
Short-finned pilot whale	*Globicephala macrorhynchus*	20 Skin biopsy	Any NWHI location

Blainville's beaked whale	*Mesoplodon densirostris*	20 Skin biopsy	Any NWHI location
Cuvier's beaker whale	*Ziphius cavirostris*	20 Skin biopsy	Any NWHI location
Longman's beaked whale	*Indopacetus pacifus*	20 Skin biopsy	Any NWHI location
Pygmy sperm whale	*Kogia breviceps*	20 Skin biopsy	Any NWHI location
Dwarf sperm whale	*Kogia sima*	20 Skin biopsy	Any NWHI location
Sperm whale	*Physeter macrocephalus*	20 Skin biopsy	Any NWHI location
Blue whale	*Balaenoptera musculus*	20 Skin biopsy	Any NWHI location
Fin whale	*Balaenoptera physalus*	20 Skin biopsy	Any NWHI location
Bryde's whale	*Balaenoptera edeni*	20 Skin biopsy	Any NWHI location
Sei whale	*Balaenoptera borealis*	20 Skin biopsy	Any NWHI location
Minke whale	*Balaenoptera acutorostrata*	20 Skin biopsy	Any NWHI location
Galapagos shark	*Carcharhinus galapagensis*	10 individuals	French Frigate Shoals

(d) What will be done with the specimens after the project has ended?

Tissue plugs from cetaceans will be retained in a DNA tissue bank for subsequent analysis. Stomach contents, liver sample, and muscle sample will be retained from sharks; remainder of shark carcass will be discarded.

(e) Will the organisms be kept alive after collection? ☐ yes ☒ no

- Specific site/location _____
- Is it an open or closed system? ☐ open ☐ closed
- Is there an outfall? ☐ yes ☐ no
- Will these organisms be housed with other organisms? If so, what are the other organisms?

(Please attach additional documentation as needed to complete the questions listed below)

9. Purpose/Need/Scope:

- State purpose of proposed activities:

Activities will fall into three categories, purposes of which are as follows: a) Monitoring and sampling of cetaceans--purpose is to obtain information on abundance and stock structure of cetacean populations within the Hawaiian Archipelago; b) Enhance survival of Hawaiian monk seal pups--Purpose is to enhance the survival of Hawaiian monk seal pups by intensive observations of shark behavior, and experimentally removing Galapagos sharks which are observed displaying predatory behavior towards monk seal pups; c) Small boat operations—purpose is to support PIFSC personnel who are monitoring Hawaiian monk seal subpopulations at Kure Atoll, Pearl & Hermes Atoll, Lisianski Island, Laysan Island, French Frigate Shoals, Necker Island, and Nihoa Island, as well as PIFSC personnel who are monitoring green turtle nesting at East Island, French Frigate Shoals.

Describe how your proposed activities will help provide information or resources to fulfill the State Marine Refuge purpose and to reach the Refuge goals and objectives.

The proposed activities are consistent with and support the purposes of the Refuge as directed by the Department, specifically §13-60 5.1 (4) "To support, promote, and coordinate appropriate scientific research and assessment, and long-term monitoring of the refuge resources, and the impacts or threats thereto from human and other activities, to help better understand, protect, manage, and conserve consistent with applicable law." The scope of the project is primarily assessment of refuge resources, viz. monitoring cetaceans and providing boat support to personnel monitoring monk seals and turtle nesting.

- Give reasons why this activity must take place in the NWHI and cannot take place in the Main Hawaiian Islands, or elsewhere.

a) Monitoring and sampling of cetaceans: Most of the cetacean species for which PIFSC has assessment responsibility occur throughout the Central and Western Pacific Ocean, and the ability and opportunity to gather data on them are limited. The proposed activity will take advantage of vessel transit to the NWHI [to support other activities of the PIFSC Protected Species Division (PSD)] by observing and sampling cetaceans, some of which may occur within the boundaries of the State Marine Refuge. Moreover, knowledge of the genetic distribution of nearshore cetacean species within the Archipelago (spinner dolphins) is required in order to assess the degree to which the populations mix. Three populations of spinner dolphins occur within the NWHI Marine Refuge (Kure, Pearl & Hermes Atoll, French Frigate Shoals).

b) Enhance survival of Hawaiian monk seal pups: As described below, survival of Hawaiian monk seal pups at French Frigate Shoals is compromised by Galapagos sharks. These events have only been documented at French Frigate Shoals, and therefore efforts to mitigate against Galapagos shark predation must occur there.

c) Small boat operations: The PIFSC monitors subpopulations of Hawaiian monk seals throughout the NWHI and, in cooperation with USFWS, monitors green turtle nesting activity at East Island, French Frigate Shoals. These activities require small boat operations within the lagoons of Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals.

- Describe context of this activity, include history of the science for these questions and background.

a) Monitoring and sampling of cetaceans: Surveys of cetaceans occurring in Hawaii are sparse, and until recently have occurred almost exclusively in and around the Main Hawaiian Islands. A single NMFS cruise in 2002 remains the only dedicated survey effort for pelagic cetaceans in the NWHI. Studies of the social structure and genetic profile of spinner dolphin populations at Midway, Pearl and Hermes Atoll, and FFS have been conducted by various universities (Andrews et al. 2005). Cetacean species occurring in Hawaii have been putatively designated by NMFS as 'Hawaiian stocks", but there are no genetic data (save for spinner dolphins).

b) Enhance survival of Hawaiian monk seal pups: see attached documentation

c) Small boat operations: The activities supported by the small boat operations have a substantial background. Monitoring of Hawaiian monk seal subpopulations in the NWHI has been conducted annually by PIFSC and its predecessor, the Southwest Fisheries Science Center since 1982. As a result, NMFS has accumulated one of the most long-term and thorough demographic research databases available for any marine mammal, and certainly one of the best for any long-lived animal of any kind. Moreover, field monitoring has identified several impediments to the recovery of the Hawaiian monk seal, including adult male seal aggression, shark predation, low juvenile survival, and entanglement, and has provided NMFS the opportunity to prevent or mitigate some of the mortality which would otherwise result from these threats. Green turtle nesting monitoring has occurred at French Frigate Shoals for 32 years. This long-term dataset has allowed for analysis and close monitoring of the status of the ESA threatened population of green turtles (Balazs and Chaloupka In Press).

- Explain the need for this activity and how it will help to enhance survival or recovery of refuge wildlife and habitats.

Monitoring and sampling of cetaceans: Under 1994 amendments to the Marine Mammal Protection Act, NMFS is charged with annually assessing the status of all marine mammal species and/or stocks which occur in U.S. waters, and as such requires data on distribution, abundance, and population structure of the 23 cetacean species whose range includes Hawaiian waters. These data provide information used by NMFS in determining the impact on marine mammal populations by human activities such as fisheries.

b) Enhance survival of Hawaiian monk seal pups: see attached documentation

c) Small boat operations: The activity is required to support seal and turtle monitoring effort. These efforts enhance recovery of refuge wildlife. Monitoring the Hawaiian monk seal population will identify threats to recovery, provide data that may be used to formulate recovery strategies for implementation. Moreover, field observations will evaluate the effectiveness of past recovery actions. The Draft Hawaiian Monk Seal Recovery Plan (HMSRP) has population monitoring as a 'priority 1' research activity ("an urgent issue that should be addressed immediately to prevent imminent decline in the population"). Moreover, the HMSRP identified four key actions required to alter the trajectory of the Hawaiian monk seal population and to move the species towards recovery. The second of the four actions states: "The extensive field presence must be maintained during the breeding season in the NWHI." Green turtle nesting monitoring data has been collected in the NWR French Frigate Shoals since 1973. The beginning years of nest monitoring data were used to help establish the low number of the breeding colony, a foundation for protection of the population for this species under State and Federal law. This population has continued to be monitored for 32 years, using East Island as a long-term Index Site.

- Describe how your proposed project can help to better manage the State Marine Refuge.

Accurate information on abundance, distribution, and factors affecting survival of Hawaiian monk seals is necessary to assess possible impacts of any management action within the Refuge, as mandated by NEPA and ESA. The State NWHI Marine Refuge, as steward for the islands, should have an accurate and thorough dataset of endangered and threatened species that utilize the region in order to protect these populations. Monitoring green turtles on East Island will provide a complete dataset of the threatened green turtle nesting population, and relevant summaries and conclusions drawn from those data. This project, since its inception in 1973, has been in partnership with the USFWS. The project to enhance survival of monk seal pups provides an effective mechanism for managing a predator which is threatening the continued presence of an endangered species subpopulation within the Refuge. Since the project started in 2000, the number of deaths and injuries to monk seals on Trig Island attributable to Galapagos sharks has diminished. Moreover, management of Galapagos sharks by selective removal of only a few individuals will not perturb the refuge ecosystem, as determined by the Ecosim model.

10. Procedures (include equipment/materials)

a) Monitoring and sampling of cetaceans: Most cetacean monitoring will occur during transit between the NWHI and will therefore be outside the Refuge boundaries. However, during camp deployment and pickup at French Frigate Shoals and/or Pearl and Hermes Atoll, small boats may be deployed to collect samples from bottlenose dolphins and spinner dolphins. Biopsy samples will be collected from free ranging animals using biopsy dart fired from a crossbow (standard methodology for collecting cetacean skin/blubber biopsies. Biopsy plugs are ~2mm in diameter and 1-2 cm long, and provide genetic information (skin) as well as data on contaminants (blubber). Note sampling of inshore populations at French Frigate Shoals and Pearl and Hermes Atoll will occur only when the O.E. Sette is in the area for field camp setup/breakdown. Field personnel who are at these two sites to monitor monk seals will not be collecting biopsy samples.

b) Enhance survival of Hawaiian monk seal pups: see attached documentation

c) Small boat operations: Whalers will be used to transport personnel among islets at Kure Atoll, Pearl and Hermes Atoll, and French Frigate Shoals, primarily for the purpose of censusing and monitoring Hawaiian monk seals, but also to transport personnel between East Island and Tern Island, French Frigate Shoals, to monitor turtle nesting. Boat operations will occur virtually daily for the duration of the project (see dates in 17. below) at Pearl & Hermes Atoll and French Frigate Shoals, and approximately every third day at Kure Atoll. At night, boats will be hauled out (French Frigate Shoals) or anchored in nearshore waters of Southeast Island (Pearl & Hermes Atoll) or Green Island (Kure Atoll). When accessing other islets within the lagoons, depending upon conditions, personnel will generally anchor the boats in shallow water adjacent to the islets, bow facing in, with a stern anchor leading offshore and a bow anchor placed on the islet. Stern anchors will always be placed on a sandy bottom. If conditions preclude safely anchoring the boat while accessing the islets, one observer will remain in the small boat as coxswain and will stay on station away from the islet while co-workers census seals.

11. Funding sources (attach copies budget & funding sources).

All projects are funded by NOAA, National Marine Fisheries Service.

12. List all literature cited in this application as well as all other publications relevant to the proposed project.

Andrews, K. R., L. Karczmarski, B. W. Bowen, S. H. Rickards, W. W. L. Au, C. Vanderlip, and R. J. Toonen. 2005. Intraspecific variability in gene flow corresponds with social system and environment for the Hawaiian spinner dolphin (Stenella longirostris). (published abstract) The 16th Biennial Conference on the Biology of Marine Mammals, San Diego, California, December 12-16, 2005.

Balazs, G. H. and M. Chaloupka, In Press. Thirty two-year recovery trend in the once depleted Hawaiian green sea turtle stock, Atoll Research Bulletin.

Balazs, G. H. and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. Biological Conservation 117(2004):491-498.

Carretta, J. V., M. M. Muto, J. Barlow, J. Baker, K. A. Forney, and M. Lowry. 2002. U. S. Pacific Marine Mammal Stock Assessments: 2002. NOAA-TM-NMFS-SWFSC-346. 286 p

13. What types of insurance do you have in place? (attach documentation) All vessels involved in supporting the research are owned by the U.S. Government and are therefore self-insured.

☐ Wreck Removal

☐ Pollution

14. What certifications/inspections do you have scheduled for your vessel? (attach documentation)

☒ Rat free ☐ tender vessel ☐ gear/equipment

☒ Hull inspection ☐ ballast water

15. Other permits (list and attach documentation of all other required Federal or State permits).

Monk seal monitoring is authorized by Scientific Research and Enhancement Permit 848-1695, issued by the NMFS Office of Protected Resources. Cetacean monitoring and sampling is authorized by Scientific Research Permits 782-1719 and 774-1714. Copies of these are attached. Permits are being requested from the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve and the Hawaiian Islands National Wildlife Refuge, and copies will be provided when they are attained.

16. Project's relationship to other research projects within the NWHI State Marine Refuge, National Wildlife Refuge, NWHI Coral Reef Ecosystem Reserve, or elsewhere.

Monk seal and turtle monitoring is part of a long term project to track the status of the affected species within the Hawaiian Archipelago. Data from cetacean monitoring will be added to data collected throughout the North Pacific as part of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) Project. Information on nearshore populations of spinner dolphins will be shared with collaborators at the University of Hawaii. Data and samples from shark monitoring will be shared with researchers from Hawaii Institute of Marine Biology as well as other appropriate researchers as part of research on contaminants, DNA, and distribution of sharks throughout the NWHI.

Section C: Logistics

17. Time Frame:

Project Start Date	Project Completion Date
April 8, 2006	~September 15, 2006

Dates actively inside the State Marine Refuge.

Nihoa Island and Necker Island

i. Nihoa and Necker will be visited if time allows via R/V O. Elton Sette ~August 5-7, 2006
ii. Leader: Chad Yoshinaga
iii. Staff: TBN, selected personnel from seal staff at each island as delineated below.

French Frigate Shoals

i. Dates: Seal Monitoring ~ April 8, through ~ September 15 (air charter); Cetacean monitoring/sampling ~ April 8-9, May 10
ii. Seal Camp Leader: Suzanne Canja
iii. Turtle Staff: George Balazs, Malcolm Gaylord, Cody Hooven, Stacy Kubis, Shawn Murakawa, Mark Rice, Konrad Schaad, Daniel Zatz,
iv. Seal Staff: TBN
v. Cetacean Leader: Dave Johnston
vi. Shark observation/removal staff: Aaron Dietrich, Dan Luers, Mark Windham

Gardner Pinnacles

i. Waters around Gardner Pinnacles will be visited if time allows via R/V O.E. Sette sometime during cruises April 6-17, May 8-23, and/or July 17-August 8.
ii. Cetacean Leader: Dave Johnston

Laysan Island

i. Dates: Setup ~April 11- R/V O. Elton Sette - Breakdown~ August 5 R/V O. Elton Sette
ii. Logistics support: R/V O. Elton Sette ~May 14
iii. Camp Leader: Gretchen Johnson
iv. Staff: Veronica de Camp, Melinda Fowler
v. Cetacean Leader: Dave Johnston

Lisianski Island

i. Dates: Setup ~April 12- R/V O. Elton Sette - Breakdown~ August 4 R/V O. Elton Sette
ii. Logistics support: R/V O. Elton Sette ~May 15
iii. Camp Leader: Jean Higgins
iv. Staff: Bert Harting
v. Cetacean Leader: Dave Johnston

Pearl and Hermes Reef

i. Dates: Setup ~May 13 - R/V O. Elton Sette - Breakdown ~ August 1 R/V O. Elton Sette
ii. Camp Leader: Hugh Finn
iii. Staff: Jessica Lopez, Kenady Reuland
iv. Cetacean Leader: Dave Johnston

Kure Atoll

i. Dates: Setup ~May 11 – R/V O. Elton Sette – Breakdown ~ July 31, R/V O. Elton Sette
ii. Camp Leader: Tracy Wurth
iii. Staff: Antonette Gutierrez
iv. Cetacean Leader: Dave Johnston

Cetacean sampling/monitoring: Field observations on cetacean distribution and abundance will occur throughout all transits of the O.E. Sette with sites/dates specified as above.
Leader: Dave Johnston
Staff: Monk seal monitoring staff as listed above.

Personnel schedule in the State Marine Refuge (describe who will be where and when).

See above

18. Gear and Materials

☐ Dive equipment ☐ Radio Isotopes

☒ Collecting Equipment ☐ Chemicals (specify types)

Collection equipment for sharks will include baited hook, bang-stick, speargun, harpoon gun, or rifle. Collection equipment for cetacean skin biopsy samples will be a biopsy dart fired by a crossbow or a small harpoon gun.

19. Fixed installations and instrumentation.

☐ Transect markers ☐ Acoustic receivers

☐ Other (specify)

No fixed installations or instrumentation will be used within the Refuge.

20. Provide a time line for sample analysis, data analysis, write-up and publication of information.

i. Monitoring and sampling of cetaceans: Data from cetacean observations will be summarized within 90 days of the completion of the surveys. Cetacean skin biopsies will be added to a tissue bank for DNA analysis, and will be analyzed within two years.

ii. Enhance survival of Hawaiian monk seal pups: A detailed report of all activities will be prepared by the end of January, 2007.

iii. Small boat operations: No summary of small boat operations will be prepared. However, the activities supported by small boat operations. Data from Hawaiian monk seal monitoring will be summarized and a summary report of 2006 activities will be prepared by the end of 2006, and published as a NOAA Technical Memorandum within 2 years. Subsamples from all necropsied seals, and all scat samples, will be sent for analysis in 2007. Similarly, biopsy samples collected from nesting turtles will be sent for analysis in 2007. Other samples, such as tissue plugs, placentae, and frozen seal serum will be archived.

21. **Vessel Information:**

Vessel Name __Oscar Elton Sette_____ IMO Number __8835097_____

Vessel Owner __U.S. Dept. of Commerce, NOAA Flag ___U.S._____

Captain's Name Cmdr. Mike Devany_____ Chief Scientist or Project Leader _Chad Yoshinaga

Vessel Type _TAGOS class research vessel_____ Call sign ____WTEE_____

Length ____68.3 m_____ Gross tonnage _____2,014_____

Port of Embarkation _____Honolulu _____

Last port vessel will have been at prior to this embarkation __Pago Pago, American Samoa____

Total Ballast Water Capacity: Volume _135,000 gal Total number of tanks on ship ____10_____

Total Fuel Capacity: _____163,000_gal_____ Total number of fuel tanks on ship ___14____

Other fuel/chemicals to be carried on board and amounts: Engines hold ~100 gallons of lube oil, but no lube oil storage tanks exist.

- Number of tenders/skiffs aboard and specific type of motors:
- Achilles
  - Quantity: 1
  - Type: Inflatable
  - Length: 14 ft.
  - Hoisting weight: 371 lbs.
  - Propulsion: 40 hp Honda outboard motor
  - Capacity: 6 persons
- Safe boat
  - Quantity: 1
  - Type: Safeboat
  - Length: 15 ft.
  - Hoisting weight: 1,340 lbs.
  - Propulsion: 90 hp Honda outboard motor
  - Capacity: 7 persons
- Rescue boat
  - Quantity: 1
  - Type: Ambar Marine, ABM-5
  - Length: 18 ft.
  - Hoisting weight: 3,949 lbs. (with 7 persons)
  - Propulsion: Twin 60 hp Mariner outboard motors
  - Capacity: 7 persons

Does the vessel have the capability to hold sewage and grey-water? Describe in detail. 6000 gal holding tank for grey & black water

Does the vessel have a night-time light protocol for use in the NWHI? Describe in detail (attach additional pages as necessary) No

On what workboats (tenders) will personnel, gear and materials be transported within the State Marine Refuge? Workboats listed above detailed to the O.E. Sette will be used to transport gear and materials between ship and shore. Workboats at each NWHI site to support the scientific research are as follows: Kure Atoll—20 ft whaler with 4 stroke Honda engine; Pearl and Hermes Atoll—two 20 ft whalers, each with two 4 stroke Honda engines; French Frigate Shoals—two 20 ft whalers, each with two 4 stroke Honda engines
How will personnel, gear and materials be transported between ship and shore? See above
If applicable, how will personnel be transported between islands within any one atoll? See above

Information for Items 9 and 10 of PIFSC, PSD application
for NWHI Marine Refuge Permit, relative to
activity b)—Enhance survival of Hawaiian monk seal pups

Background and Overview

Predation on Hawaiian monk seals by large sharks has been well documented in several reports (Kenyon and Rice 1959, Balazs and Whittow 1979, Rice 1964, Alcorn and Kam 1986). The actual act of predation by sharks on Hawaiian monk seals is rarely observed, and frequently researchers have only been able to assess bite wounds or scars from shark attacks (Hiruki et al. 1993). While shark predation has been a known mortality source for many decades, until recently, it was not identified as a major limiting factor in any monk seal subpopulation.

Recent studies have shown that shark predation *has* been a significant factor contributing to early pup mortality at FFS, particularly at Trig Island.[1] A significant number of pup deaths or disappearances related to shark predation have been either directly observed or inferred from previous events associated with shark predation on pups. Two factors are considered when inferring the occurrence of shark predation, and distinguishing predation losses from those attributable to other factors, most notably aggressive males. The first is that females intensely defend their pups from adult males during lactation (Johanos et al. 1994); the second is that males inflict distinctive scars and lacerations (Hiruki et al. 1993). Therefore, shark predation is inferred when unweaned pups disappear and there is no evidence of male interaction or other factors likely to compromise pup survival (such as severe storms). Most mortality or injury from sharks involves nursing pups, but analysis of historical data indicates that weaned pups are also attacked.

Research initiated in 1997-1998 indicated that Galapagos shark (*Carcharhinus galapagensis*) was the shark species responsible for the escalation in predation losses at Trig Island. In 1998, a number of individually identified Galapagos sharks patrolled Trig Island repeatedly within the same season, and exhibited distinct predatory behavior. Although Galapagos sharks have been previously reported to prey on pinnipeds, (Compagno 1984), they most commonly forage on fish and cephalopods (Compagno 1984, Wetherbee et al. 1996), and predation on Hawaiian monk seals was not documented prior to 1997 (Craig et al. 1999). Predation losses remained high from 1997-99, but declined after an active research presence was established at Trig Island in 2000. In 2000-2004, Galapagos sharks remained the only species identified attempting to prey on pre-weaned monk seal pups in shallow water, <2 m in depth, at Trig Island. Observational studies, bite radii, and teeth spacing of shark injuries to pre-weaned pups also indicate that the preponderance of pup wounds were inflicted by Galapagos sharks. However, we suspect that at least some of the recent pup disappearances at East Island may be attributable to tiger sharks, which frequently prey on fledgling albatross.

---

[1] Data on shark predation rates and trends presented herein are excerpted from the following reports which may be referenced for additional information on the methodology used to collect and analyze predation data: Hayes 2001, NMFS 2003, NMFS 2004, NMFS 2005.

This pattern of intense shark predation is exceptional. Over two decades of monk seal studies indicate that Galapagos shark predation on pre-weaned pups is a very unusual behavior that is unique to Trig Island and, more recently, other sites at French Frigate Shoals. It is not a known cause of pre-weaned pup mortality at other monk seal reproductive sites in the NWHI. We believe that a small group of Galapagos sharks frequenting Trig I and possibly now ranging atoll-wide, has learned to prey on pre-weaned monk seal pups and is responsible for most of the predation.

The escalation of Galapagos shark predation on pre-weaned pups may be related to a period of adult male monk seal aggression that resulted in several pup deaths at Trig Island. Pup carcasses remaining in the surrounding waters of Trig I. after adult male interactions may have attracted the Galapagos sharks to a new prey resource, which led to the recently observed predation problem. Male aggression at Trig I. was a significant cause of pup mortality in 1997 and was mitigated in 1998, but Galapagos sharks have continued to target pre-weaned monk seal pups as prey.

Previous efforts have been made to prevent shark predation at Trig I. by non-lethal means. In 2000, studies were initiated to document the occurrence of Galapagos shark predation on pups and to deter predation by hazing (jabbing with long pole while attempting to tag, throwing pieces of dead coral and other debris found on beach) sharks frequenting water <2 m in depth. The 2000 study served as a pilot investigation, the study was refined in 2001, and data collection was fully implemented in 2002-2003. In 2004-2005, the intensive shark monitoring conducted at Trig in 2000-2003 was suspended in favor of more broad-scale investigations atoll-wide.

Given the information obtained over the last nine years (1997-2005), it is possible that shark predation on Hawaiian monk seal pups at French Frigate Shoals will escalate if efforts to mitigate the problem do not continue. An example of such a problem occurred at Sable Island, Canada where harbor seal (*Phoca vitulina*) pup survival declined from over 600 to 40 within a nine year period as a result of shark predation (Lucas and Stobo 2000).

Summary of Long-Term Shark Predation Trends at FFS
For purposes of data compilation and analysis of historical data, possible predation incidents are divided into three classes:

- *Confirmed* mortalities or attacks (carcass or pup observed with shark inflicted wounds)
- *Probable* mortalities (confirmed mortalities + pup disappearances preceded by observed shark-inflicted wounds)
- *Possible* mortalities or attacks (both of above categories + disappearances inferred to be predation due to absence of any other compromising factors)

Using these categories, the dynamics of the shark predation phenomenon at FFS (1997-2005) can be summarized as follows:

- At Trig/Whaleskate, the number of *possible mortalities* (recall that *possible* includes both observed injuries and inferred losses) peaked in 1997-1999 (18-28 *possible* mortalities each

year) and declined thereafter (less than 10 possible mortalities each year). There were 3-4 possible mortalities in 2002-2004, and 6 in 2005.

- The proportion of pups born at Trig/Whaleskate that were *possible attack* victims also peaked in 1997-99 (38-69% of the annual cohort). The proportion attacked was less than 20% from 2002-2004, but increased to 29% in 2005 (Figure 1),.

- The number of attack incidents elsewhere in the atoll has increased from less than 10% of pups born at non-Trig sites attacked in 1997-99, to approximately 17-18% of the annual cohort in 2000-2002, 31% in 2003-2004, and back to 18% in 2005 (value are *possible* attacks which includes confirmed injuries and kills plus inferred predation losses).

- Atoll-wide, the number of *possible mortalities* has been more-or-less stable the last five years, with 10-12 losses each year (10 in 2005). These losses account for 15-21% of the annual cohort born at FFS (19% in 2005). The number of possible shark attacks (lethal and non-lethal) atoll-wide has ranged from 23-30% of the annual cohort since 2000 (23% in 2005).

In the subsequent sections, these trends are described in greater detail for Trig Island and the rest of FFS, respectively.

Summary of 2005 Predation Events at FFS
There were a total of 52 pups born at FFS in 2005, of which 10 (19%) were believed to be victims of shark predation. Another 4 pups disappeared due to unknown causes: those losses *may* have been due to shark predation, but evidence was inconclusive to attribute the losses to shark predation. If those 4 pups are treated as shark-related mortalities, the total cohort loss becomes 27%.

The 10 losses attributed to shark predation in 2005 included the following incidents:
- Trig Island (24 born; 6 mortalities): 1 confirmed kills, 3 shark-inferred disappearance, and 2 wounding with subsequent disappearance
- Round Island (2 born; 1 mortality): 1 shark-inferred disappearance
- Gin Island (1 born; 2 mortalities): 1 kill and 1 shark-inferred disappearance
- Shark Island (1 born 1 mortality): 1 shark-inferred disappearance

Predation rates and trends at Trig Island (all years)
At Trig Island, both the number of shark attacks and number of mortalities peaked in 1997-1999 and declined thereafter, but has been increasing since 2002 (Figures 1-2). The high of 28 possible mortalities in 1997 (Figure 1) differs from some previous tabulations because the earlier analyses failed to include older nursing and near-weaning losses as possible shark mortalities. The intensive observational data from the last five years has led to the recognition that older pups are vulnerable to shark predation, and hence they are included here as possible shark mortalities.

The raw numbers of pups attacked or killed may be misleading because the total number of pups born at the Trig/Whaleskate complex has declined in the last six years (Figure 1). If the predation data are interpreted in relation to the number of pups born at the two islands, it is apparent that although the predation rate has declined after 1999, the proportion of the annual cohort lost to predation has been edged upward each year from 2002-2005 (Figure 2).

Prior to 2000, predatory sharks were commonly observed at Trig Island during daylight hours. Since an active research presence was established on Trig Island in 2000 (combined with shark removals and various levels of shark harassment), the shark sighting rate has markedly declined and shark predatory behavior is now largely nocturnal. The fact that the population continues to suffer predation losses, although Galapagos shark sightings are generally low, indicates that the predatory activity is now confined primarily to crepuscular and/or nocturnal hours, when researchers are not present.

Figure 1. Shark mortalities (known and inferred) at Trig and Whaleskate Islands, 1984-2005. (see text for description of the known, probable, and possible mortalities).

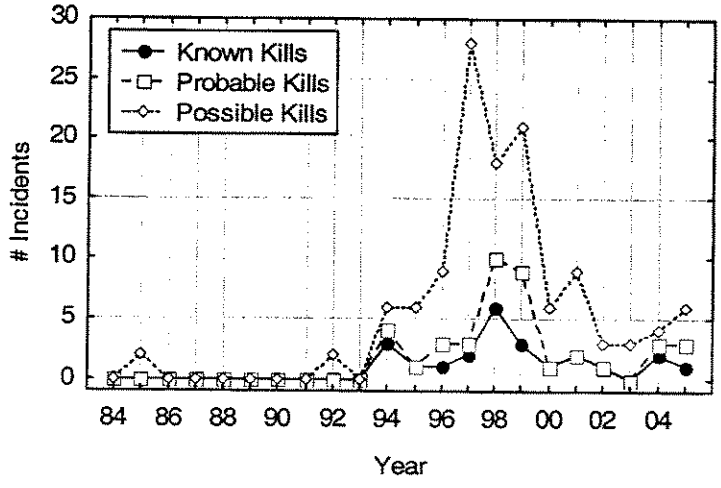
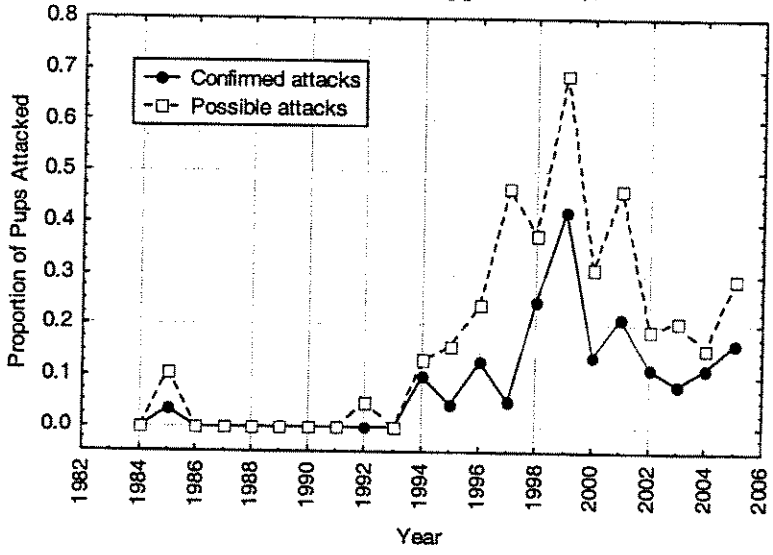


Figure 2. Proportion of pups born at Trig and Whaleskate attacked by sharks (confirmed kills/injuries and inferred kills from unexplained disappearances), 1984-2005.



Shark Predation at other Sites at French Frigate Shoals (all years)

Atoll-wide, shark attacks and mortalities have declined since the peak in 1997-99 (Figure 3). However, as predation has decreased at Trig Island (Figures 1-2), it has tended to increase at the other sites (Figure 4-5) so that Trig Island now accounts for a smaller proportion of the total (atoll-wide) predation documented each year. Most of the apparent increase belongs in the "shark-inferred" category (a component of the *possible mortalities/attacks* as displayed in the figures: unexplained pup disappearances with no indication of other compromising factors). With fewer numbers of pups being born at FFS (as compared to the peak in the late-1990s), the predation is taking a heavy toll on a smaller cohort: approximately 24% of the 2004 cohort was attacked, with 18% of the cohort believed lost to shark predation (Figure 6). Clearly, the apparent metastasis of shark predation from a localized phenomenon at Trig to an atoll-wide issue is of grave concern to the conservation of monk seals at French Frigate Shoals.

Figure 3. Number of possible mortalities atoll-wide at FFS, 1984-2005

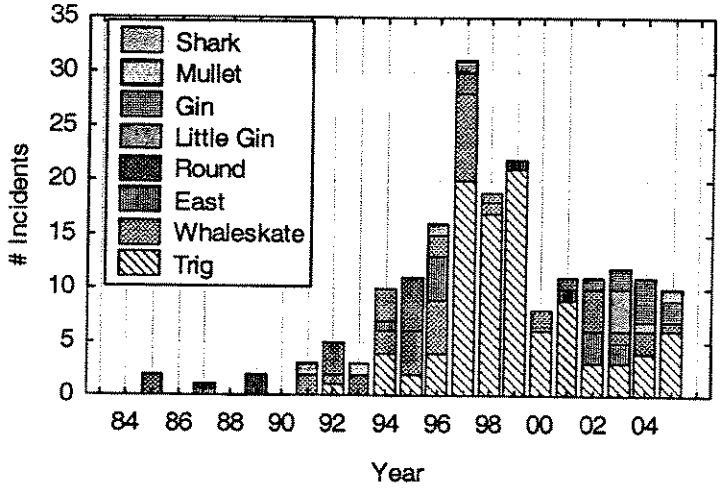


Figure 4. Number of attacks at all FFS sites except Trig/Whaleskate, 1984-2005

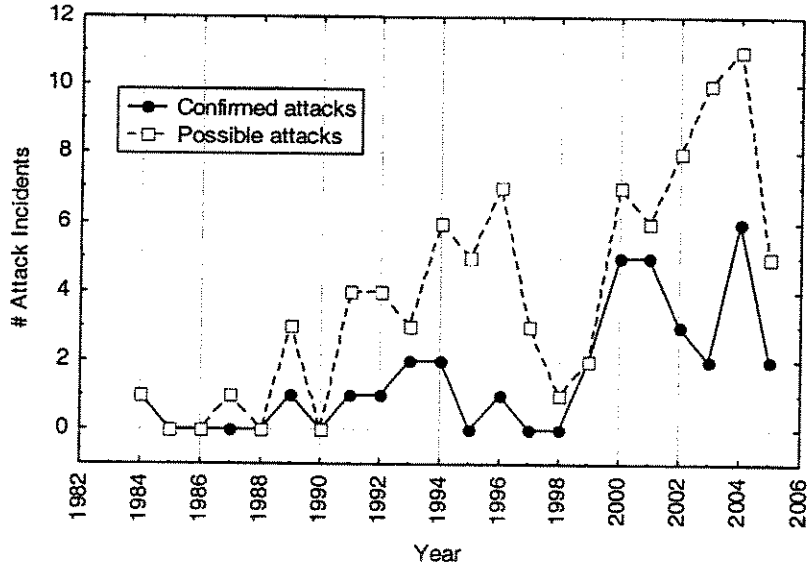


Figure 5. Number of predation mortalities at all FFS sites except Trig/Whaleskate, 1984-2005

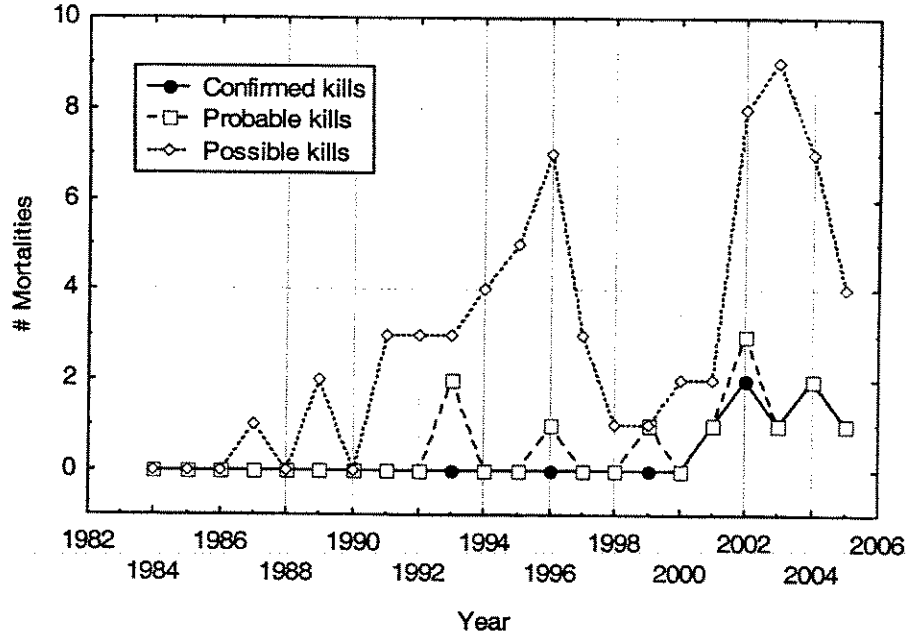
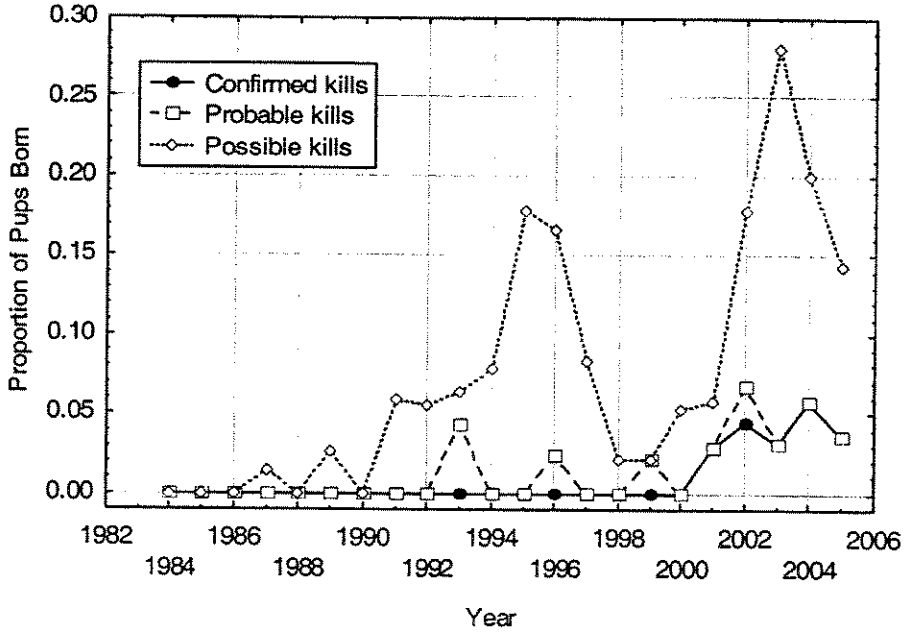


Figure 6. Proportion of the annual cohort born at all FFS sites except Trig/Whaleskate, (1984-2005) that were killed by sharks



Previous Experimental Efforts Related to Shark Predation

A number of strategies and techniques have been attempted to reduce the vulnerability of monk seal pups to predatory Galapagos sharks. Irregular shark observations were incidentally conducted in 1998-1999 by members of the monk seal population assessment team. Activities included non-standardized observations and limited tagging of individual Galapagos sharks in 1999 (Craig et al. 1999).

Beginning in 2000 (and continuing through 2003), standardized protocols for shark monitoring were implemented at Trig Island, and the removal of Galapagos sharks engaged in predatory behavior was authorized. Intentional hazing of Galapagos sharks at Trig I. in 2000 and 2001 did not eliminate predation on pre-weaned pups, but did cause sharks to become extremely wary of human presence. No hazing was conducted in 2002-2004 in favor of a less obtrusive research presence. Results from the monitoring project indicate a substantial reduction in shark density at Trig Island from 2000-2005, although each year a number of pups are victims of inferred shark predation (see previous discussion of predation trends). The fact that the population continues to suffer predation losses, although Galapagos shark sightings are generally low, suggests that the predatory activity is now confined primarily to crepuscular and/or nocturnal hours, when researchers are not present. This activity pattern is unlike that observed in 1998-99 when sharks were frequently observed engaged in predatory behaviors during daylight hours (Antonelis pers. comm.).

From 2000-2005, 12 Galapagos sharks have been removed from Trig Island using conventional hand line and a hand-held harpoon (2000: 1 shark; 2001: 5 sharks; 2002: 2 sharks; 2003: 2 sharks; 2004: 0 sharks; 2005: 2 sharks). All fishing efforts in 2005 were conducted at Trig Island, although in previous years, limited fishing was conducted at Round Island. One of the two sharks taken in 2005 was taken with a harpoon, and the other using a hand-line.

Non-lethal deterrents such as nets, bubble nets, electromagnetic fields, physical barriers, and relocation have been considered, but they pose a threat to monk seals (e.g., entanglement) and/or would displace of Galapagos sharks to other locations where they might initiate their predatory behavior at new sites (harassment would have the same effect as exclusion) and potentially amplify the problem over time. Also, we have concern that these deterrents (e.g., electromagnetic fields) would unnecessarily displace other sharks such as gray reef sharks, which are not engaged in predatory behavior.

V. Review and Evaluation of the Experimental Shark Removal Program

An Environmental Assessment for the proposed experimental removal of Galapagos sharks at Trig Island was completed in 2002 (NMFS 2002). The preferred alternative identified in that document included the experimental removal of Galapagos sharks exhibiting predatory behavior toward monk seal pups at Trig Island The project was expanded in 2003 to allow shark monitoring and removal at other sites in French Frigate Shoals where Galapagos shark predation

had been observed. The spread of the predation to other sites was anticipated as the ongoing removal efforts at Trig caused the sharks to alter their behavior (see 2004 and 2005 SUP Reports). The positive results obtained at Trig Island from 2000-2003 suggested that, if applied atoll-wide, the same methodology could be instrumental in improving the survival of monk seal pups at other sites, and was a required component of monk seal conservation at FFS. The atoll-wide initiative was formalized with the 2003 addition of Round Island and Whale-Skate Islands to the Trig Island study[2]. Possible effects of the atoll-wide removal program on the coral reef ecosystem at FFS were investigated using the *EcoSim* model. Results from that work indicated that the removal of 20 sharks (the initial number permitted in the EA) had a nearly imperceptible effect on the dynamics of the ecosystem (Parrish unpublished data 2005).

Under the terms of the EA and ancillary agreements, only Galapagos sharks displaying active predatory behavior to pre-weaned seals can be targeted for removal. Sharks of other species (tiger sharks, gray reef sharks, and others), and Galapagos sharks not engaged in apparent predatory interactions with monk seal pups *may not be removed.* Criteria for assessing predatory behavior are given in the Methodology and Appendix A of this application.

The working hypothesis around which the preferred alternative in the EA was designed was that the pool of actively predating Galapagos sharks was small (relative to their total population size), and swift removal of up to 40 sharks in one to two seasons would deplete their numbers and successfully alleviate the predation crisis. The removals were designed as an "experiment" in the sense that the removals would be conducted in association with intensive monitoring and research on shark numbers, behavior, and movements, thereby enabling a quantitative assessment of the project's success.

The project has not proceeded as originally conceived, due largely to the fact that predating sharks modified their behavior patterns, so as to be more wary of human activity and gear, to a degree not anticipated when the EA was drafted. Despite the intensive fishing effort by highly skilled personnel, less than one-third of the 40 sharks stipulated in the EA have been removed over a longer time period. The project, as realized, incorporates elements of both Alternatives 1 (removals) and 2 (harassment) of the EA, with the latter element largely an artifact of inefficient removal methods (see below). Nonetheless, the reduction in predation losses at Trig Island (50-70% as compared to the 1997-1999 levels) is likely a result, in whole or in part, of the ongoing shark removals and the harassment that accompanies shark observation and fishing. However, with the current removal protocols, the program is more likely to moderate rather than alleviate predation intensity. If efforts are not made to become more efficient at removal, then the experiment will be more difficult to assess because it becomes more like an ongoing "maintenance" effort for monk seal conservation at FFS, rather than an intensive short-term mitigation measure.

---

[2] June 4, 2003 verbal approval to take Galapagos sharks at Round Island under authority of Special Use Permit 12521-03021, and to relocate uninjured pups from Round and Whale-Skate Islands under authority of Special Use Permit 12521-03011.

The remaining Galapagos sharks engaged in monk seal predation respond to human activity by avoiding, or being extremely cautions in areas where humans are present. In response to these changes in shark behavior, several capture methods have been attempted with varying levels of success. These include hand-line fishing, hand-held harpoon, and a spear gun. The primary capture method to date, and the only available method of take for sharks beyond 5 meters of shore (but still within the permitted depth of $\leq$ 2m) is fishing from shore with a hand-line. As sharks have become increasingly wary of human activity at Trig Island, this method is rendered extremely inefficient. The speargun and harpoon are also inefficient because the sharks are extremely wary of humans and remain out of range.

The efficiency of the current shark culling protocols was evaluated through a simple catch-per-effort analysis compiled from the shark observation and capture data. A total of 10 sharks have been hooked over 6 field seasons using the "hook and line technique". Of these sharks, 8 have been culled and one was hooked and lost. These numbers include five sharks from 2001, four of which were captured after seal flesh was added as an acceptable part of the fishing protocol. In spite of a substantial increase in observation and fishing effort since 2001, only three sharks have been captured by a baited hook and line. The effort expended includes over 2,470 hours of observation time dedicated solely to monitoring shark predatory behavior.

No more than two sharks were taken in any year except 2001, when five sharks were removed. Project biologists have noted that the sharks have become increasingly cautious when approaching the baited hook: Although the fishing effort in 2005 was the highest since the project began, few sharks showed even passing interest in either seal or fish bait. The one shark that was captured was hooked on the placenta of a seal born that morning, suggesting a strong preference for extremely fresh, unfrozen seal flesh. Unfortunately, this "ultra" fresh bait is only available when a pup has been born in the past two hours. Freezing and handling of seal tissue by humans likely imparts an odor that the sharks can detect and illustrates the need for a new method of capture.

Table 1. Observation effort, fishing effort, and number of sharks caught/hooked at FFS, 2002-2005. Observation time expressed in number of 15-minute observation blocks and corresponding hours.

	Total time blocks observation	Shark sighted # time Blocks	Trig fishing effort (bait in water)	Round fishing effort (bait in water)	Caught	Hooked/not landed
2002	3774 (943.5 hr)	77 (16d)	12d (18h 53m)	0	1 (Trig)	0
2003	3718 (929.5 hr)	21 (10d): Trig 15 (3d) Round	9d (7hr 43m)	3d (5h 52m)	1 (Trig)	1 (Round)
2004	697 (174.25 hr)	11d	3d (7hr 30m)	0	0	0
2005	1694 (423.5 hr)	141 (28d)	15d (28hr 24m)	0	1	0

As further indication of the extent to which sharks have become more cautious over the life of the project, ,there have been no confirmed injuries on any seals during observation hours since 2001, despite the considerable observation effort expended from 2002-2005. This suggests that sharks now hunt differently, and perhaps more aggressively, during times when human are not present. These findings reinforce the need for a more effective shark removal strategy to achieve the project objective to mitigate predation losses as outlined in the EA.

VI. Methods

In the *Methods* which follow, certain additions to the 2003-2005 protocols are proposed to better adapt the study design to the increased predation at non-Trig sites, and the nocturnal predation pattern at all sites. New provisions proposed for implementation in 2006 include the remote monitoring system on Trig (and possibly one other site), and the option to use a small caliber charged harpoon gun and high-powered rifle for more effective shark removal. To facilitate agency review, new components of the project appear in bold.

A. Shark Monitoring and Shark Fishing

1. *Time-scan sampling:* As in 2004-2005, the regimen of intense shark observations (i.e., *time-scan sampling*) undertaken at Trig Island in 2000-2003 will be not be undertaken in 2006 in favor of the more mobile shark predation response effort (see below). Limited time-scan sampling will be conducted, using the established protocols, under the following conditions: 1) a major recrudescence of shark activity at Trig Island occurs (as detected by excessive pup losses or direct observations of patrolling sharks), 2) personnel are available to conduct the observations, and 3) determination by NMFS that significant new findings (in terms of our understanding of the shark/seal dynamic) are likely to accrue from an intensified shark monitoring effort. The specific monitoring protocols are described in *Appendix A.*

2. *Pre-dawn fishing:* As per the agreement in 2005, pre-dawn fishing will be allowed when the shark team overnights at a site. This time period is specified because of the additional safety afforded by increasing (rather than waning) light, and the option for additional boat support (as required) during approved Refuge boating hours. Optionally, predating sharks may be harpooned from shore, using floats equipped with VHF transmitters for later relocation and removal of the shark.

3. *Trig Island Monitoring:* Monk seal population assessment personnel will continue to visit Trig Island on a daily or near-daily basis so that missing pups, shark-injured pups, or elevated shark activity will be immediately detected. If sharks are observed, monitoring intensity will be immediately increased to evaluate the predation risk (see item 6).

4. *Fishing personnel:* Two persons experienced in safe and effective methods for shark fishing/removal will be assigned to the monk seal program at FFS. These persons will serve a dual role for population assessment and shark removal work. They will participate in the ongoing assessment work until such time as shark activity warrants their reassignment to address that concern.

5. *Shark monitoring without fishing:* Once shark activity and/or shark predation has been documented at an islet, the shark team (or the monk seal assessment team) may periodically visit the islet to conduct shark monitoring observations not associated with a fishing effort. This monitoring will be primarily conducted from the boat to ensure that no seals, turtles, or other species will be disturbed by the monitoring activities. Shore-based observations may be authorized by the NMFS camp leader on larger islets such as the Gins. Shark observational data will be collected using the protocols established at Trig Island, 2001-2003 and adapted for Round Island in 2003.

6. *Predation alert protocol:* All personnel engaged in monk seal population assessment at FFS will be alert for evidence of shark predation at any site within the atoll. If Galapagos sharks are observed displaying predatory behaviors, they will immediately notify the shark fishing team and will begin collecting observational data using the protocols established at Trig Island, 2001-2003 and adapted for Round Island in 2003 (approved by FWS on June 4, 2003). They will remain on site whenever possible until the fishing team has arrived (contingent upon other duties).

7. *Pre-fishing monitoring:* When the shark team is dispatched to a site to conduct fishing, the objective will be to monitor shark behavior for a minimum of 30 minutes before initiating any fishing operations. This objective will be tempered by pup safety considerations. Specifically, if 1) any pup is in a situation where it may be vulnerable to shark predation, and 2) sharks are displaying active predatory behavior, then fishing may be immediately initiated.

8. *Criteria for classifying shark predatory behavior* will conform to the previously established guidelines. During the period when shark observations are underway (including while bait is in the water), shark activity will be coded using the following categories:
   - Code 1: Cruising, remains in water >2m depth and shows no behavior directed towards monk seal pups; no obvious signs of predatory behavior.
   - Code 2: Patrolling, repeated passes in water less than/equal to 2m depth; apparently hunting pups.
   - Code 3: Makes directed approach to seal
   - Code 4: Charges seal, clearly attempts to attack
   - Code 5: Injures or kills pup

9. *Criteria for Removal:* Seven years of intensive observations at Trig Island (1997-2003) have revealed that Galapagos sharks hunt or pursue pre-weaned monk seal pups in shallow water ($\leq$2 m) during monk seal pupping season. This behavior was persistent and predictable and can be used to target individual sharks for removal. Galapagos sharks identified for removal will have exhibited conspicuous predatory behavior, defined as actively pursuing or hunting for pre-weaned pups in water less than two meters deep (Codes 2-5, above). (To ensure reliability in species identification and interpretation of shark predatory behavior, at least one member of the shark fishing team will have previously participated in the shark monitoring and fishing program at Trig Island).

10. *Effective Sighting Area for Fishing:* Fishing activities will be confined to a predefined effective sighting area around each islet. For Trig Island, the effective sighting area will be defined as waters less than two meters in depth, remaining within ¼ mile radius from the island. For sites other than Trig, the sighting/fishing area will be waters of any depth within 100 m from the islet.

11. *Fishing/Removal methods from shore (Trig-fishing):* Once a shark has been targeted for removal, bait will be deployed from shore so that it remains within the effective sighting area. Bait soak time will be limited to one hour following the last sighting of a targeted shark to reduce the possibility of attracting additional sharks to the area. Currents will be noted, and the bait will be placed in an area that will avoid any risk of scent emanating from the bait to attract other sharks or put seals at additional risk. To optimize the ability to catch sharks attempting to prey on monk seal pups, fishing from shore may require deploying bait from a kayak in water $\leq$ 2 m and up to 20 meters from shore. A kayak may be used to ensure proper placement of the baited hook. The line will be tended at all times to ensure that only the targeted Galapagos sharks are hooked. No personnel will enter the water during culling activities. Predatory Galapagos sharks will be taken by one of three methods described below:
    Targeted Galapagos sharks may be caught from shore using a single baited hook that can always be seen by the fisher. When a shark is hooked, it will be brought to shore and euthanized with a 44-cal. "bang stick."

A spear-gun may be used as an alternative to hooking. A barbed shaft, shot from a spear-gun, will be attached to wire cable and connecting line that will be used to retrieve sharks to the beach for euthanasia.
A hand-held harpoon may be used. The harpoon will have a detachable barbed head tethered to a line which will be used to haul the shark to shore for euthanasia. A small caliber (.223) charged harpoon gun will also be used in 2006. This device can be fired in the air at Galapagos sharks attempting to prey on monk seal pups. A similar device was used to propel darts for the collection skin samples from dolphins last summer.

12. *Use of high-powered rifle:* This option will be added to the available shark removal options for 2006. The only individual authorized to handle or operate a rifle will be a designated marksman, with certified credentials in the proper use of firearms (law enforcement, military, or other formal training). This individual will be selected by NMFS and approved in advance by FWS. The only site where firearm use will be permitted will be from the shore of Trig Island (central sand flat extending from the south shore of the island). During removal operations, the marksman will be attended at all times by the NMFS shark team (Dan Luers and/or Aaron Dietrich) who will identify the target shark, conduct shark observations, and ensure that the operation does not endanger monk seals or other resources. Details are provided below:

- In response to observed or suspected shark activity, the marksman will accompany NMFS shark personnel to Trig Island. Once a Galapagos shark enters the observation area, the marksman will remain on standby while the NMFS team determines if the shark is exhibiting predatory behavior

- Attempts to remove a shark by shooting will be abandoned unless all of the following criteria are met:
  - The shark is confirmed as fitting the criteria for removal as outlined in the research permit
  - Water visibility is good to excellent (shooting operations will not be conducted if the water is murky or other factors limit water visibility because of increased difficulty in retrieval efforts)
  - There are no seals at risk within or near the firing zone
  - The marksman confirms he is visually following the correct shark

  If all criteria are satisfied, the marksman will prepare the high powered rifle to dispatch the shark.

- One or both shark observers will move to the 17' Boston Whaler anchored just off the northern shore (opposite the observation/firing line area) and prepare the boat for launch. This will be quickly accomplished using a quick release anchor line/anchor buoy set up so the boat can be under way in less than one minute. On the boat will be a handheld harpoon with retrieval line and a long gaff for carcass retrieval. If deemed

necessary, one observer may temporarily remain with the marksman to assist with tracking the target shark.

- The marksman will wait for the targeted shark to move into the predetermined boundaries which will allow for the greatest chance for retrieval of the carcass. The boundaries will be centered on the large sand flat south of the observation area, will extend out 20 meters from the south shore of the island, and will span approximately 40 meters in length. This area is regularly used in the patrolling/hunting patterns observed, is surrounded by shallower reefs which would help to initially contain the carcass until retrieval, and would allow for a clean firing line from the beach with no islands behind the target area.

- Using handheld VHF radios the marksman will confirm that all of the above criteria are met, and the shark observers will confirm that the boat is ready for quick launch to begin retrieval procedures.

- Once a shot is fired, the boat team will launch the boat and quickly move to the south side of the island. The marksman will use a hand held radio to confirm if the shot found the target and help direct the boat team to the carcass.

- The shark carcass will be loaded onto the boat immediately, and brought to shore for biological sampling as described elsewhere in the methodology.

13. *Fishing on or in vicinity of small islets (non-Trig fishing):* At Trig Island, fishing will be conducted primarily from shore, unless circumstances indicate that boat-fishing would be more productive. At other sites, fishing from the boat is the preferred method, but experience gained at Round Island in 2003 indicates that in some cases, fishing from the boat may not be an efficient means for catching sharks. This is because the inability to enter the water from the boat hampers the use of the speargun; depth and complex reef topography may severely restrict boat-based operations; prevailing currents and limitations on suitable boat placement may make it difficult to deploy bait downcurrent of the islet; and the boat can act as a deterrent to the approach of sharks. In situations where boat-based fishing is impractical or ineffective, the shark team may fish from shore providing that the following factors are considered:[3]
    - Shark monitoring data will continue to be collected primarily from the boat prior to removal efforts, and during removal efforts if personnel are available
    - An assessment of the number of total seals, M/P pairs on island (as well as their activity/sensitivity levels) indicates that on-island fishing will not result in excessive disturbance or displacement of seals
    - The monk seal field camp leader will be consulted prior to landing whenever possible

[3] These conditions are based on provisions of the June 2003 agreement between NMFS and USFWS regarding shark fishing at Round Island

- No sharks will be landed on small islets (including Round Island). All sharks which are harpooned, speared, or caught with a hook will be allowed to run a short distance from the island before being retrieved by the boat
- Under most circumstances a single person would be deployed on island while the second person would re-anchor the boat a short distance away (both personnel will be in constant visual/radio contact, and the boat person will be ready to pick the person up from the island within 1-2 minutes time)
- The length of time personnel remain on-island will be contingent on the disturbance risk imposed by their presence. This will be determined according to such factors as the number of total seals present, the number of M/P pairs, any injured seals on-island, and the distribution and activity levels of seals, and the reaction of the seals to the person on-island. If personnel can remain on island safely without unacceptable disturbance they will remain so even after the targeted shark or sharks exit the sighting area (in practice the person will likely remain on-island for 1-2 hours following the last sighting, provided conditions are acceptable; many sharks have been observed to return to the area within a 2 hour period following departure).
- All sharks will be landed and euthanized from the boat and all necropsies will be performed on the boat, unless circumstances such as weather or impending darkness prevent an on-board necropsy. In these instances, the carcass will be transported to a suitable shore site for necropsy. The necropsy and shark disposal protocol will be the same as is in effect under present permit conditions.

Removal effort at non-Trig locations may occur in water of any depth within 100 m of the islet. Predatory shark behavior (Codes 2-5 above) towards mothers/pups may occur on shallow reefs adjacent to islets, and also adjacent to water deeper than 2 meters; this may necessitate fishing activities in water >2 m deep. In all such cases, fishing efforts will cease at any time that the fishers are no longer confident that the shark being targeted is the same individual as was observed exhibiting the predatory behavior.

Removal methods will be the same as used at Trig: baited hook, harpoon, small caliber harpoon, rifle, or speargun. Procedures will be identical to those used at Trig except the boat will be the preferred fishing platform, rather than shore.

14. *Use of artificial seal*: In all instances, once a shark has displayed predatory behavior sufficient for it to be selected for removal, researchers may use mock-up of a monk seal pup to attract the shark. Procedures for using the mock-up will be similar to those for using bait. The mock-up will be deployed from shore, boat, or kayak so that it remains within the effective sighting area. The mock-up will usually be deployed *after* the bait has been deployed, so the soak time will generally be less than one hour (the time limit for bait). The mock-up will be used *only after* a shark has exhibited aggressive behavior toward pups or mother-pup pairs as defined above, and has been selected for removal.

15. *Additional safety considerations:* All removal operations will be conducted so as not to endanger nearby monk seals by attracting or concentrating sharks to an area where pups are vulnerable. Also, the fishing team will exercise prudent judgment in determining whether all conditions (environmental conditions, physical setting, and other) are conducive to safe and successful operations without incurring undue risk to themselves, their equipment, or other resources.

16. *Number of sharks:* This application requests lethal take of up to 15 Galapagos sharks. Additional removals may be permitted if continued mitigation is considered necessary. Galapagos sharks will be removed in increments of five using the techniques described above. After the removal of the fifth Galapagos shark, a field report of research activities and removal efforts will be provided to a joint USFWS/NMFS review panel to determine if the culling activity should cease. The review panel will be given up to two days to review the information and make a determination. The decision to continue removing sharks will be based on an evaluation of the possible impacts to other wildlife (e.g., turtles), compliance with the terms of the permit, and the report of activities supplied by field personnel.

17. *Removal locations:* Shark removal may occur at any of the emergent islets within French Frigate Shoals where monk seal pups are present and Galapagos sharks have exhibited distinct predatory behavior as determined using the aforementioned criteria. However, as previously noted, removals are only allowed at the time predatory behavior is observed (that is, fishing is *not* allowed if a pup loss was recently detected, but no active predatory behavior is currently underway).

18. *Shark Carcass Handling and Disposal:* As noted above concerning fishing on islets other than Trig, necropsies will be conducted in the boat wherever possible. In all cases, Galapagos shark necropsies will be performed at locations where blood, viscera, and other remains will not enter the water. After all samples and data have been collected, shark carcasses either will be discarded at the closest deep water location outside of the refuge, or, per B. 24 below, will be tested/used as deterrents.

19. *Fishing effort and post-removal reports:* As agreed upon by FWS and NMFS (August 18, 2001), information concerning the removal of each shark will include environmental conditions at the time of removal, criteria used to determine the shark targeted for removal, identifying tags and physical features of the shark removed, history of previous shark sightings, removal methodology, and method of euthanasia. Information collected from each shark carcass will include morphometric measurements, genetic samples, stomach contents, and reproductive status. Tissue samples from sharks will be analyzed to quantify compounds of potential concern at acceptable detection limits to include total metals, polychlorinated biphenyls, organochlorine pesticides, percent lipid and moisture, and fatty acid analysis for possible detection of monk seal consumption.

B. Other Investigations (adjunct studies)

1. *Galapagos shark research:* NMFS will evaluate the feasibility of new techniques for analyzing the movement patterns (geographic and temporal), and population size of Galapagos sharks at French Frigate Shoals, with an emphasis on determining the origin and composition of the population component engaged in monk seal predation. Action on this item will be contingent on funding availability. Researchers at the University of Hawaii are in the process of conducting a large scale "connectivity" study in the NWHI that includes Galapagos sharks. FWS has issued a SUP for this work and is aware of its value for the determination Galapagos shark movement patterns near FFS.

2. *Trophic ecosystem simulations:* The *EcoSim* model has been used to evaluate the effects of shark removal on the biota of the atoll. While the results from that effort support the conclusion of no adverse impact to the FFS ecosystem, additional *EcoSim* runs may be completed if additional data on shark numbers or other key components of the ecosystem are acquired.

3. *Galapagos shark deterrent investigations:* The development of effective non-lethal shark deterrents is an active research area that has obvious application to the issue of shark predation on monk seal pups. FWS has previously encouraged NMFS to explore non-lethal options for protecting monk seals. Compounds associated with the scent of decaying sharks have shown particular promise in early trials (see http://sharkdefense.com/). PSD is collaborating with other institutions to test the efficacy of using decayed shark carcasses to deter sharks. If the technique shows promise in tests at other sites, PSD may apply for an amendment to the Permit to test the procedure at French Frigate Shoals.

VIII. References

Alcorn, D. J., and A. K. H. Kam. 1986. Fatal attack on a Hawaiian monk seal, (*Monachus schauinslandi*). Mar. Mamm. Sci. 2:313-315.

Balazs, G. H., and G. C. Whittow. 1979. First record of a tiger shark observed feeding on a Hawaiian monk seal. 'Elepaio 39:107-109.

Compagno, L. J. V. 1984. Sharks of the World, FAO Fisheries Synopsis Part 2, 25 (4): 655 pp.

Craig, M. P., M. Shaw, G. Mo, and M. Rutishauser, 1999. Aggressive male behavior and shark predation dramatically increase mortality of Hawaiian monk seal pups at French Frigate Shoals. Abstract in 13th Biennial Conference on the Biology of Marine Mammals, Nov.-28 Dec. 3, 1999, The society for Marine Mammalogy, Wailea, Maui, Hawaii.

Hayes, S. 2002. Galapagos shark predation of monk seal pups at Trig Island, FFS, 2001. U.S. Dep. Comm., NOAA internal report. Pacific Island Fisheries Science Center, Honolulu, HI. 22 pp.

Hiruki, L. M., W. G. Gilmartin, B. L. Becker, and I. Stirling. 1993. Wounding in Hawaiian monk seals (*Monachus schauinslandi*). Can. J. Zool. 71:458-468.

Johanos, T. C., B. L. Becker, and T. J. Ragen. 1994. Annual reproduction cycle of the female Hawaiian monk seal (*Monachus schauinslandi*). Mar. Mam. Sci. 10(1):13-30.

Kenyon, K.W., and D. W. Rice. 1959. Life history of the Hawaiian monk seal. Pac. Sci. 13:215-252.

Lucas, Z. and W.T. Stobo. 2000. Shark-inflicted mortality on a harbour seal (Phoca vitulina) population at Sable Island, Nova Scotia. J. Zool. 252(3): 405-414.

National Marine Fisheries Service. 2003. Shark predation at Trig Island, 2002. Internal report (draft). Prep. by Harting Biological Consulting, Bozeman, Mont. for U.S. Dep. Comm., Pacific Island Fisheries Science Center, Honolulu, HI. 53 pp.

National Marine Fisheries Service. 2004. Shark predation at French Frigate Shoals 2003. Internal report (draft). Prep. by Harting Biological Consulting, Bozeman, Mont. for U.S. Dep. Comm., Pacific Island Fisheries Science Center, Honolulu, HI. 50 pp.

National Marine Fisheries Service. 2005a. Shark predation at French Frigate Shoals 2004. Internal report (draft). Prep. by Harting Biological Consulting, Bozeman, Mont. for U.S. Dep. Comm., Pacific Island Fisheries Science Center, Honolulu, HI. 37 pp.

National Marine Fisheries Service. 2005b. Shark predation at French Frigate Shoals 2005. Internal report (draft). Prep. by Harting Biological Consulting, Bozeman, Mont. for U.S. Dep. Comm., Pacific Island Fisheries Science Center, Honolulu, HI. 17 pp.

Rice, D. W. 1964. The Hawaiian monk seal: rare mammal survives in leeward islands. Nat. Hist. 73: 48-55.

Wetherbee, M. W., G. L. Crow, C.G. Lowe. 1996. Biology of the Galapagos shark, *Carcharhinus galapagensis*, in Hawai'i. Envir. Bio. Fish : 299-310.

APPENDIX A: Protocols for Shark Monitoring

The time-scan sampling protocol described below was designed to collect the requisite data for detecting daily and seasonal changes in shark numbers and behavior, before and after shark removal events, and in different years. In addition to monitoring shark activity, information is also gathered on island-specific seal activity, including daily mom/pup pair identifications and locations, and number of weaned pups present at each site. All activity related to shark fishing/removal will be documented. Following a shark removal, a full necropsy will be completed, tissue samples collected, and shark removal report forms completed to document the known history of the shark and other pertinent data related to the event. Whenever feasible, data are collected to aid in the identification of individual Galapagos sharks. This effort includes maintaining field "scar cards" depicting unique features of individual sharks and a digital database of shark images.

Time-Scan Sampling Data Collection Protocol
Time-scan sampling involves the continuous scanning to record all sharks present during consecutive 15-minute time blocks (*sampling intervals*), and all discrete behaviors exhibited by those sharks. Data fields on the time scan sampling forms are:

Date: mmddyy

Time: The beginning of each fifteen-minute time block refers to the continuous sighting effort of the fifteen minutes following the time entered.

Observer: The initials of the person who is recording the data for that specific time block.

Condition Code: Used to characterize the likelihood of observing sharks which enter the sighting area, throughout any given sampling interval. Affected primarily by sun angle-dependent surface glare, wind and/or swell induced chop, and the presence or absence of suspended particulate matter. The following three sighting condition codes are used:

0-Ideal: less than or equal to 33% of the sharks present throughout the entire sighting area, and sampling interval, are likely to be missed if present; or less than 50% of the entire sighting area is a code 1; or less than 33% of the entire sighting area is a code 2.

1-Acceptable: most sharks likely to be detected; or between 33% and 66% of the sharks present throughout the entire sighting area are likely to be missed if present; or less than 50% of the entire sighting area is a code 2.

2-Poor: light/wind/silt make it likely some sharks will be missed if present; greater than 66% of sharks present within the entire sighting area, and sampling interval are likely to be missed if present; or greater than 50% of the entire sighting area is a code 2.

Note: For the following six data variables, information is collected twice, once at the beginning and again at the end of the sampling interval. In all cases, the larger of the two figures is recorded.

Tot M/P: Total number of mother-pup pairs present on the islet

Vis M/P: Total number of mother-pup pairs visible to the observer. Note: The pup must be visible for the pair to be visible.

M/P in H20: Total number of mother-pup pairs in the water (subset of above). Location of pup is used, if only one member of the pair is observed in the water. An animal is also considered to be in the water if it is being splashed by water when sampling occurred.

Tot W: Total number of weaned pups present.

Vis W: Total number of weaned pups visible to the observer

W in H2O: Total number of weaned pups in the water (subset of the above). Note: An animal is also considered to be in the water if it is being splashed by water when sampling occurred.

Fish/Tag Event: Used to record whether or not fishing/removal occurred at any time during the sampling interval.

Note Y/N: Used to indicate whether or not a handwritten note pertaining to the current sampling interval is made. Notes addressed the following specific topics:

- •The occurrence of area-wide seal-related events such as time of births and weanings, time of injury, death, or disappearance, pup switching, etc.
- •The effects of outside environmental factors (those other than solar angle, which remains relatively consistent from day to day), such as increased wind or cloud cover on sighting conditions.
- •The effect of outside factors on data collection
- •Fishing activity, including when and where a Galapagos shark is first and last sighted and what types of culling activities took place, and fishing results.
- •If a shark is observed well enough to determine the presence or absence of individual-specific identifying features, a note is also made as to which individual it is, or if clearly lacking readily identifiable characteristics is labeled a "clean fin."

4.

Shark Activity: Data on shark activity including the species, estimated length, minimum number of sharks, and the shark behavior observed throughout any given sampling interval. This method is consistent with that used during previous seasons and allows for the

quantification of overall shark activity levels, as well as a behavioral analysis. Shark behavior is categorized into five different behavioral category codes and divided into discrete behavioral "events" based on these codes. For each category code, the total number of behavioral events is recorded (next to "events"), along with the minimum number of sharks engaged in that activity (next to "sharks"). The latter is based on continuous observation, individual-specific identifying characteristics, size, and/or the simultaneous observation of multiple sharks. If there is no clear basis for distinguishing individual sharks, then the minimum number is "1." An "event" began either when a shark is first observed, or a shark already being actively followed switched behavior to a different code. An "event" terminates when a shark is lost from view or switches behavior to engage in a different behavior.

The behavioral codes are defined as follows:

Code 1: Cruising in >2m depth, no obvious signs of predatory behavior.
Code 2: Patrolling, apparently hunting pups in <2m depth.
Code 3: Makes directed approach to seal
Code 4: Charges seal, clearly attempts to attack
Code 5: Injures or kills pup

Shark Species Separation

A separate data field exists for each of the three most common shark species: Galapagos, gray reef, and tiger sharks. All other species are recorded in the other data field by species. The following species codes are employed:
U=unidentified, WTR=white-tip reef, BTR=black-tip reef, BT=blacktip, S=sandbar, and UH=unidentified hammerhead. The number of discrete shark sighting "units" (the minimum number of sharks seen during a single 15-minute observation time block) is recorded in the number data field by shark species.

Size class codes are based on the total length estimate for each shark sighted and are as follows: Class 0, Unknown; Class 1, <6ft ; Class 2, ≥ 6 & <7ft ; Class 3, ≥7 & <8ft; Class 4, ≥ 8 & <9ft; Class 5, ≥9ft. When multiple sharks are observed, the total would be recorded under the corresponding size class followed by the number of individuals in parenthesis. For example, sighting one shark with an estimated total length (TL) of 7.5 ft and two with unknown sizes would be recorded as 3-(1), 0-(2).

Shark Tags Seen (Y/N): dictating whether any external shark tags (i.e., HVT dorsal fin, spaghetti, satellite, etc.) are observed on any sharks during a given time block. Note: an N indicates either no tags present or the shark is not observed well enough to determine presence/absence of tags.

Weekly Minimum: The larger of a) the most sharks observed simultaneously within the sighting

area, or b) the minimum number of individually identifiable sharks observed within the sighting area throughout a seven-day period ending Sunday. This is filled out once weekly on Sunday, or if no observations are conducted Sunday, the closest preceding day data are collected. Note: This number is not a sum of daily minimum number of Galapagos sharks sighted

Additional Data Collection Methods

Additional information surrounding island-specific seal activity, fishing/removal effort, and individual-specific shark identification is collected. Births, weanings, and pup exchanges are recorded when first observed. Additional noteworthy seal observations are recorded opportunistically.

APPENDIX B: Modeling Shark Removal at French Frigate Shoals

Use of Ecological Model to Evaluate Removal of Galapagos Sharks from French Frigate Shoals, Northwestern Hawaiian Islands[4]

Frank Parrish
Pacific Islands Fisheries Science Center
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii 96822

Background

The Pacific Island Fisheries Science Center (PIFSC) has requested a permit from the U.S. Fish and Wildlife Service (FWS) to allow for the selective removal of up to 10 Galapagos sharks at French Frigate Shoals (FFS). This proposal is a continuation of the experimental shark removal program implemented by PIFSC in 2000-2005 under separate permits. The intent of the experimental removals is to reduce the intense shark predation pressure on pre-weaned monk seal pups at Trig Island and (more recently) elsewhere in the atoll (details provided in PIFSC annual shark project progress reports).

To date, 10 Galapagos sharks exhibiting predatory behavior in the waters around seal nursery beaches have been removed at FFS (one in 2000, five in 2001, two in 2003, and none in 2004). The removal program is complemented by a comprehensive shark monitoring and seal population assessment program designed to assess the annual predation rate and the shark response to the selective removals. Prior to renewing the shark removal permit, FWS has requested an ecological appraisal of the proposed shark removals to determine the likely response of the system to removal of a small number of apex predators. This document outlines the appraisal that was conducted.

Methods

The analysis utilized the ECOPATH ecological/ecosystem modeling software suite, which is ideally suited for evaluating ecosystem responses to selected perturbations (Christensen and Walters 2004a,b). The ECOPATH suite has three main components: *Ecopath* – a static, mass-balanced snapshot of the system; *Ecosim* – a time dynamic simulation module for policy exploration; and *Ecospace* – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas. This analysis used the first two of these components. This model has been previously tested and refined for specific application to the Northwestern Hawaiian Islands (Polovina 1984).

---

[4] PIFSC Internal Report IR-05-003
Issued 15 April 2005

The only population estimate for Galapagos sharks at FFS comes from a fishing survey conducted in the early 1980's (DeCrosta 1984). That survey produced an estimate of 703 Galapagos sharks for FFS. However, because the survey was an area-based estimate derived from long line sets, it is likely that the estimate was inflated due to shark attraction to bait.

An alternate Galapagos shark population estimate was derived using a revised version of the FFS ECOPATH model. The model used as a reference the area-based standing biomass of reef fish as measured on surveys conducted in all of the atoll's primary habitats, with the amount of each habitat determined from *Ikonosis* imagery. The measured fish belong to taxa with high site fidelity. Large transients such as shark and jack are not included in the reference taxa. The reef fish biomass is supplemented by diet, growth and reproductive studies to project the prey, algae, and zooplankton needed to support the reference biomass. The number of apex predators, including sharks, that feed on the reference biomass can then be quantitatively estimated.

The estimate thus obtained is a theoretical population size derived from the amount of food (reef fish) seen in the atoll and the law of thermodynamics. Estimating shark population size in this fashion requires the assumption that the sharks only feed at FFS and do not travel or forage outside of the atoll. If some sharks *do* forage outside the atoll, the resulting population estimate will be biased low (i.e., the actual number of sharks may be higher than the ECOPATH estimate) due to the energy influx from non-modeled habitats.

Results

Galapagos shark population estimate

The estimated number of Galapagos sharks at French Frigate Shoals derived from the ECOPATH model is between 86 and 275. This population number was then used in an ECOSIM model to provide a dynamic simulation of the ecosystem response when sharks are removed.

Ecological effects of additional shark removals

The ecological effect of removing 10 sharks within a ten year period was addressed with three different model scenarios spanning 15 years. Each of the scenarios included the 10 Galapagos sharks that were removed in the first five years (2000-2004) of the project. The first scenario removed one shark every year for 10 years beginning in 2005. The second scenario removed 2 sharks every year for five years beginning 2005. The third scenario removed 5 sharks for 2 years beginning 2005.

In all three scenarios, the ecosystem change over the 15-year period deviated from equilibrium less than 1%. The presence of jacks, tiger sharks and grey reef sharks which fill the same ecological niche as the Galapagos dampens any impact to the ecosystem associated with the

removal of the Galapagos sharks.

The ECOPATH population estimate (86-275 sharks) is well below the 703 sharks estimated from the area-based longline surveys. Also, because it is possible that at least some of the sharks present at FFS range outside the atoll, the ECOPATH estimate may underestimate the shark population. If that is the case, then the ecosystem change predicted by ECOSIM may be an upper bound on the actual perturbation effect.

Literature Cited

Christensen, V., and Walters, C. J. 2004a. Ecopath with Ecosim: methods, capabilities and limitations. Ecological Modelling.

Christensen, V., and Walters, C. J. 2004b. Trade-offs in ecosystem-scale optimization of fisheries management policies. Bulletin of Marine Science 74(3):549-562.

DeCrosta, M.A., 1984. Age determination, growth, and energetics of three species of carcharhinid sharks in Hawaii. M.S. Thesis, Department of Oceanography, University of Hawaii, Honolulu. 65 p.

Polovina, J. 1984. Model of a coral reef ecosystem. Coral Reefs 3:1-11.

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of NOAA Corps Operations
NOAA Ship OSCAR ELTON SETTE
#1 Sand Island Access Road
Honolulu, HI 96819-2222

16 February 2006

MEMORANDUM FOR: CDR Michael Devany, NOAA
Commanding Officer, NOAAS OSCAR ELTON SETTE

FROM: LT Kurt Dreflak, NOAA
Field Operations Officer, NOAAS OSCAR ELTON SETTE

SUBJECT: Hull Inspection Report

Ship's divers completed a series of hull inspection and maintenance dives on the NOAA ship OSCAR ELTON SETTE on 15 February 2006 while the ship was underway south of American Samoa. Divers involved included by LTJG Bejamin Sniffen, LCDR James Bunn, LT Kurt Dreflak and CDR Michael Devany. Surface support was provided by SST Phil White and CDR Jane Powers. The following was noted during the inspection:

HULL: The hull was found to be in excellent condition after the January cleaning by US Army Divers, aided by ship's divers. Fouling was minimal.

PROPELLERS: The Starboard shaft and propeller were slightly entangled with a small piece of net. Divers cleared all netting from the Starboard shaft and propeller. Otherwise, both propellers, shafts, and all bearings appeared to be in good condition.

RUDDERS: Both rudders were in good condition and not fouled.

BOW THRUSTER: The bow thruster was in good condition and free of line. One long line hook with a small amount of leader was removed from the grating on the Starboard side.

TRANSDUCERS: The ship's transducers were free from major marine growth. All bolts on plates installed in December to cover the transducer ports were tight. Transducer plates were in excellent condition. Some corrosion was present on select lock washers.

ZINCS: Slightly oxidized. Forward zinc on Port side was missing a small piece, but epoxy is holding well.